## REMARKS

This Amendment is fully responsive to the non-final Office Action dated June 2, 2011, issued in connection with the above-identified application. The fee for a one-month extension of time is included. Claims 2-8 are pending in the present application. With this Amendment, claims 2, 3 and 5 have been amended; and claims 4 and 6-8 have been cancelled without prejudice or disclaimer to the subject matter therein. No new matter has been introduced by the amendments made to the claims. Favorable reconsideration is respectfully requested.

In the Office Action, claims 2-8 are rejected under 35 U.S.C. § 103(a) as being unpatentable over Tsukamoto et al. (U.S. Publication No. 2004/0026381, hereafter "Tsukamoto") in view of Terada et al. (U.S. Patent No. 5,155,329, hereafter "Terada"), Chou et al. (U.S. Patent No. 5,961,859, hereafter "Chou") and Kearney (U.S. Patent No. 4,446,354, hereafter "Kearney").

Claims 4 and 6-8 have been cancelled thereby rendering the above rejection to those claims moot. Additionally, the Applicants assert that the above cited prior art fails to disclose or suggest all the features recited in independent claims 2 and 3.

For example, independent claim 2 recites the following features:

"[a] laser welding method, comprising:

varying a waveform and a frequency of a laser output in a controlled manner so as to prevent occurrence of weld defects;

detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion;

analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which is a same variation frequency of the laser output; and

setting a laser output variation condition such as the waveform and the frequency so that the amplitude of the frequency component becomes a maximum."

Preventing weld defects greatly depends on "a waveform of the variation" and "a frequency of the variation" in the laser output, so it is important to optimize conditions of variations in the laser output. The present invention (as recited in independent claim 2) has determined that the peak of the amplitude in the frequency component of the light emission of a plasma or a plume which matches with the variation frequency of the laser output is the largest at optimum welding conditions (see Applicants' disclosure pg. 9, lines 3-8 and Fig. 4).

The welding method of the present invention (as recited in independent claim 2) detects a time change in light emission strength of a plasma or a plume generated from a laser welded portion; analyzes frequency characteristics of the light emission to obtain an amplitude of a frequency component which is the same variation frequency of the laser output; and sets a laser output variation condition such as the waveform and the frequency so that the amplitude of the frequency component becomes a maximum.

In the Office Action, the Examiner relies on the combination of Tsukamoto, Terada, Chou and Kearney for disclosing or suggesting all the features recited in independent claim 2. However, the Applicants respectfully disagree.

Independent claim 2 recites:

*"varying a waveform and a frequency of a laser output in a controlled manner so as to prevent occurrence of weld defects."*

The Examiner alleges that ¶[0032] of Tsukamoto discloses or suggests the above features of the varying step recited in claim 2. Tsukamoto in ¶[0032] discloses that in a practical welding operation and through the observation of movement of a wave occurring on the surface of the molten metal, the frequency of a pulse modulation of the laser output may be conformed to the natural oscillation frequency of the molten metal.

Tsukamoto (i.e., ¶[0032]) also discloses a laser welding method for preventing welding defects by modulating a laser output in accordance with the frequency of a molten-pool (i.e., the periodic movement of the molten metal). That is, a pulse laser output is controlled to conform to the frequency of the reciprocating motion of molten metal (see also e.g., ¶[0026]-¶[0027]). The frequency, however, of a welded portion is not controlled.

Additionally, in Tsukamoto (i.e., ¶[0032]), porosity is prevented by resonating oscillation of a molten pool by corresponding the natural oscillation frequency with the laser output variation frequency. However, Tsukamoto fails to disclose or suggest varying a waveform and a frequency of a laser output in a controlled manner so as to prevent occurrence of weld defects, as recited in independent claim 2.

Independent claim 2 recites:

*"setting a laser output variation condition such as the waveform and the frequency so that the amplitude of the frequency component becomes a maximum."*

It appears that the Examiner alleges that ¶[0034]-¶[0036] of Tsukamoto discloses or

suggests the above features of the stetting step of claim 2. Tsukamoto (i.e., ¶[0034]-¶[0036]) discloses that welding defects can be controlled by individually controlling output frequency as well as a pulse rise time (tu), a peak output time (tp), a pulse fall time (td), a base output time (tb), a peak output (WP) and a base output (WB) of a laser output. As described in Tsukamoto (i.e., ¶[0034]-¶[0036]), the pulse frequency of the laser output is controlled to conform to the molten-pool natural oscillation frequency.

The Examiner also points out that Tsukamoto (i.e., ¶[0034]-¶[0036]) discloses or suggests a minimum threshold of about 10 ms being set to the rise time (tu). However, in Tsukamoto, there is no mention of setting a laser output variation condition such as the waveform and the frequency, let alone setting such a laser output variation condition so that the amplitude of the frequency component becomes a maximum, as recited in independent claim 2. As noted above, Tsukamoto only discloses that the rise time (tu) of a laser output can be set to 10ms.

As noted above, Tsukamoto (i.e., ¶[0034]-¶[0036]) discloses that welded defects can be prevented by varying a laser output with natural oscillation frequency of a metal molten pool and by controlling a wave form of the laser. However, preventing welding defects is largely dependent on a waveform and a frequency of an output modulation. Accordingly, it is necessary to optimize a condition of the output modulation. In Tsukamoto (i.e., ¶[0034]-¶[0036]), it is difficult to determine an optimum condition of the output modulation since there is a need for: 1) welding performed under several conditions where the frequency and the waveform of the output modulation are different, 2) detection of defects in a welded portion, and 3) setting a condition such that the amount of defects are reduced at some optimum condition.

With the present invention (as recited in independent claim 2), a time change in light emission strength of a plasma or a plume generated from a laser welded portion is detected and the time change is analyzed. Thus, an optimum condition of an output modulation is promptly and more easily determined. The present invention (as recited in independent claim 2) is substantially different from the laser welding method disclosed by Tsukamoto for at least the reasons noted above.

Additionally, independent claim 2 recites:

*"detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion"* and

*"analyzing frequency characteristics of the light emission to obtain an amplitude of a*

*frequency component which is a same variation frequency of the laser output."*

It appears that the Examiner relies on the combination of Terada, Chou and Kearney for disclosing the above features of claim 2, which the Examiner acknowledges is lacking in Tsukamoto (see Office Action, pg. 3). In particular, the Examiner relies on Fig. 4 and 6 and col. 4, lines 33-43 of Terada; col. 3, lines 8-18 of Chou; and Kearney generally.

Terada, with reference to Figs. 4 and 6, discloses a relationship between a waveform of the pulsating laser beam and a waveform of the emission intensity at a weld zone. As described in Terada, the waveform related to emission intensity stays at a certain level while the welding beam input is present, and decreases abruptly a short time after the welding beam input drops (see also col. 4, lines 33-43).

Thus, Terada in the description of Figs. 4 and 6 merely discloses a correlation or relationship between the welding beam input and emission intensity at a weld zone. Terada fails to disclose or suggest detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion and analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which is a same variation frequency of the laser output.

Terada in col. 4, lines 63-66 also discloses that a predetermined wavelength used in filtering the light emitted at the molten pool can be determined by performing welding testing, spectrum analysis and data processing. Thus, only a light emitted from a molten pool is detected, and a welded depth and a laser output are monitored because light strength corresponds to a laser output and a welded depth. Thus, in Terada (i.e., col. 4, lines 63-66), a light emitted from a plasma is not detected. Instead, a light emitted from a molten pool is detected.

Further, Terada in Fig. 1 discloses the use of a sensor disposed over a welded portion to detect a light emitted from a molten pool, not light emission of a plasma or a plume. Thus, the light source for detection is different between Terada and the present invention (as recited in independent claim 2). Accordingly, Terada fails to disclose or suggest detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion and analyzing frequency characteristics of the light emission to obtain an amplitude of a frequency component which is a same variation frequency of the laser output, as recited in independent claim 2.

Chou in col. 3, lines 8-18 discloses a method of monitoring laser weld quality. The

method includes monitoring, at a position above a surface and as a function of time during the laser welding process, the spatial distribution of the intensity of light emitted from a plasma. Additionally, a numerical value is assigned to at least one physical dimension of the plasma to monitor the intensity of light, and the numerical value is compared to a predetermined value, wherein the predetermined value is representative of acceptable weld quality.

In Chou (i.e., in col. 3, lines 8-18), a light emitted from the weld plasma above the surface of a workpiece irradiated by a laser beam is monitored. However, the size of the plasma is determined from the light emission and compared to a predetermined value that produces welds of acceptable quality. Thus, in Chou (i.e., col. 3, lines 8-18) monitoring of a welding condition is performed by detecting light emission, but an optimum welding condition is still not determined.

Conversely, with the present invention (as recited in independent claim 2), an optimum condition of an output modulation is determined by detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion and analyzing frequency characteristics of a time change in light emission strength of a plasma or a plume.

Therefore, neither Terada nor Chou disclose or suggest all the features of the "detecting' and "analyzing" steps recited in independent claim 2. Additionally, Kearney fails to overcome the deficiencies noted above in Terada and Chou. In the Office Action, the Examiner does not point to a particular section of the reference, but merely states that Kearney discloses that it is well known that the amplitude and wavelength of radiation emitted by a welding arc or plasma is detected by a sensor to determine weld conditions. Based on review of Kearney, the reference also fails to disclose or suggest the "detecting" and the "analyzing" steps recited in independent claim 2.

As noted above, with the present invention (as recited in independent claim 2), an optimum condition of an output modulation is determined by detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion and analyzing frequency characteristics of a time change in light emission strength of a plasma or a plume. As shown in the attached Fig. A, a change of a laser output over a time change in a plasma emission strength is disclosed. An optimum frequency for preventing porosities is around 20Hz or 22.2Hz. As can be seen from Fig. A, the plasma emission strength varies in response to the variation of the laser output at the optimum laser power variation frequencies (20, 22.2 Hz.).

With the present invention (as recited in independent claim 2), in order to quantitatively examine whether a change of plasma emission corresponds to an output change, analysis of frequency characteristics of a plasma emission waveform are conducted by, for example, a first Fourier transforming method (FFT analysis) and the amplitude of each frequency component is examined.

The attached Fig. B shows a result from analysis of frequency when welding with an output variation at 16.7Hz. Accordingly, whether a plasma emission waveform corresponds to an output variation waveform or not is understood by conducting frequency analysis of a plasma emission variation in several conditions and comparing the amplitude of the frequency component of the output variation frequency. An optimum output variation condition is determined so that the amplitude of the frequency component of the laser output variation frequency has a maximum value. No such features are believed to be disclosed or suggested by the cited prior art.

For at least the reasons noted above, no combination of Tsukamoto, Terada, Chou and Kearney would result in, or otherwise render obvious, the features of independent claim 2. Likewise, no combination of Tsukamoto, Terada, Chou and Kearney would result in, or otherwise render obvious, the features of claim 5 at least by virtue of its dependency from independent claim 2.

With regard to independent claim 3, the claim recites:

"[a] laser welding method, comprising:

varying a waveform and a frequency of a laser output in a controlled manner so as to prevent occurrence of weld defects;

detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion;

setting an arbitrary threshold value to the time change in the light emission strength of the plasma or the plume; and

setting a laser output variation condition so that a sum of time at which the light emission strength becomes the threshold value or less is a minimum,

wherein laser output variation condition is set such that the sum of the time at which the light emission strength becomes the threshold value or less is set to a range between 2ms to 12ms."

Independent claim 3 has similar features to those of independent claim 2. Accordingly, independent claim 3 is believed to be distinguished from the cited prior art for similar reasons noted above for independent claim 2. For example, independent claim 3 also recites:

*"varying a waveform and a frequency of a laser output in a controlled manner so as to prevent occurrence of weld defects;" and*

*"detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion."*

Again, the Examiner alleges that ¶[0032] of Tsukamoto discloses or suggests the above features of the varying step of claim 3. However, Tsukamoto (i.e., ¶[0032]) merely discloses a laser welding method for preventing welding defects by modulating a laser output in accordance with the frequency of a molten-pool (i.e., the periodic movement of the molten metal). That is, a pulse laser output is controlled to conform to the frequency of the reciprocating motion of molten metal (see also e.g., ¶[0026]-¶[0027]). The frequency, however, of a welded portion is not controlled.

Additionally, in Tsukamoto (i.e., ¶[0032]), porosity is prevented by resonating oscillation of a molten pool by corresponding the natural oscillation frequency with the laser output variation frequency. Tsukamoto fails to disclose or suggest varying a waveform and a frequency of a laser output in a controlled manner so as to prevent occurrence of weld defects, as recited in independent claim 3.

It appears that the Examiner also relies on the combination of Terada, Chou and Kearney for disclosing the above features of the detecting step of claim 3, which the Examiner acknowledges is lacking in Tsukamoto (see Office Action, pg. 3). In particular, the Examiner relies on Fig. 4 and 6 and col. 4, lines 33-43 of Terada; col. 3, lines 8-18 of Chou; and Keaney generally.

As noted above, Terada in the description of Figs. 4 and 6 merely discloses a correlation or relationship between the welding beam input and emission intensity at a weld zone. Terada, in col. 4, lines 63-66, discloses that a light emitted from a plasma is not detected. Instead, only a light emitted from a molten pool is detected. Additionally, the light source for detection is different between Terada and the present invention (as recited in independent claim 3). Accordingly, Terada fails to disclose or suggest detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion, as recited in independent

claim 3.

Chou in col. 3, lines 8-18 discloses a method of monitoring laser weld quality. In Chou (i.e., in col. 3, lines 8-18), a light emitted from the weld plasma above the surface of a workpiece irradiated by a laser beam is monitored. However, the size of the plasma is determined from the light emission and compared to a predetermined value that produces welds of acceptable quality. Thus, in Chou (i.e., col. 3, lines 8-18) monitoring of welding condition is performed by detecting light emission, but an optimum welding condition is still not determined.

Conversely, with the present invention (as recited in independent claim 3), an optimum condition of an output modulation is determined by detecting a time change in light emission strength of a plasma or a plume generated from a laser welded portion and analyzing frequency characteristics of a time change in light emission strength of a plasma or a plume.

Therefore, neither Terada nor Chou disclose or suggest all the features of the "varying and "detecting" steps recited in independent claim 3. Additionally, Kearney fails to overcome the deficiencies noted above in Terada and Chou.

Moreover, since Terada, Chou and Kearney fails to disclose or suggest the "varying" and "detecting" steps of independent claim 3, it logically follows that the references also fails to disclose or suggest the following features of independent claim 3:

*"setting an arbitrary threshold value to the time change in the light emission strength of the plasma or the plume; and*

*setting a laser output variation condition so that a sum of time at which the light emission strength becomes the threshold value or less is a minimum,*

*wherein laser output variation condition is set such that the sum of the time at which the light emission strength becomes the threshold value or less is set to a range between 2ms to 12ms".*

For at least the reasons noted above, no combination of Tsukamoto, Terada, Chou and Kearney would result in, or otherwise render obvious, the features of independent claim 3.

In light of the above, the Applicants respectfully submit that all the pending claims are patentable over the prior art of record. The Applicants respectfully request that the Examiner withdraw the rejections presented in the outstanding Office Action, and pass the present application to issue.

The Examiner is invited to contact the undersigned attorney by telephone to resolve any issues remaining in the application.

Respectfully submitted,

Susumu TSUKAMOTO et al.

/Mark D. Pratt/

By 2011.10.03 14:06:37 -04'00'

Mark D. Pratt
Registration No. 45,794
Attorney for Applicants

MDP/lkd
Washington, D.C. 20005-1503
Telephone (202) 721-8200
Facsimile (202) 721-8250
October 2, 2011